

CLAIMS

What is claimed is:

1 1. A method of detecting leaks in an
2 extracorporeal blood circuit, comprising the steps of:
3 detecting fluid outside a first portion of a
4 blood circuit;
5 detecting air inside a second portion of a blood
6 circuit located remote from said first portion such that
7 fluid is not detectable from said second portion;
8 generating an alarm signal responsively to a
9 result of either or both of said steps of detecting.

1 2. A method as in claim 1, wherein said first
2 step of detecting includes providing a fluid sensor below
3 said circuit first portion and sensing a presence of blood
4 with said sensor.

1 3. A method as in claim 1, wherein said second
2 step of detecting includes applying a positive gauge
3 pressure to said circuit during a first time and applying a
4 negative pressure to said blood circuit during a second
5 time.

1 4. A method as in claim 1, wherein said step of
2 generating includes generating an alarm if either of said

3 first and second steps of detecting results in an
4 indication of a leak.

1 5. A method as in claim 1, wherein said second
2 step of detecting includes periodically reversing a flow in
3 said blood circuit.

1 6. A method as in claim 1, wherein said second
2 step of detecting includes positioning a funnel with a
3 fluid detector under a blood processing machine.

1 7. A method as in claim 1, wherein said second
2 portion includes tubing linking a patient to a blood
3 processing machine.

1 8. A method as in claim 7, wherein said first
2 portion includes a portion of said blood circuit at least
3 partially housed by a blood processing machine.

1 9. A method as in claim 8, wherein said step of
2 detecting fluid includes directing a flow of fluid by
3 gravity by means of a funnel to a fluid detector.

1 10. A leak detection system for an
2 extracorporeal blood circuit, comprising:

3 a fluid detector located in a position to capture
4 leaking blood from a first portion of said blood circuit;

5 a mechanism in said blood circuit to, at least
6 periodically, create a negative pressure in all portions of

7 a patient side of said blood circuit such that any leaks in
8 said all portions will result in infiltration of air;

9 an air infiltration detector located to detect
10 air infiltrating said second portion;

11 an alarm connected to both said air infiltration
12 detector and said fluid detector and configured to generate
13 an alarm signal if either said air infiltration detector or
14 said fluid detector indicates a leak.

1 11. A device as in claim 10, further comprising
2 a container positioned with respect to said fluid detector
3 to guide blood leaking from said blood circuit toward said
4 fluid detector.

1 12. A device as in claim 10, wherein said
2 mechanism includes a device adapted to reverse flow in said
3 blood circuit.

1 13. A device as in claim 12, wherein said device
2 adapted to reverse flow includes a reversing valve.

1 14. A device as in claim 13, further comprising
2 a funnel-shaped container positioned with respect to said
3 fluid detector to guide blood leaking from said blood
4 circuit toward said fluid detector located at a bottom of
5 said container.

1 15. A device as in claim 14, wherein said
2 funnel-shaped container is built into a housing of a blood
3 processing machine of which said blood circuit is a part.

1 16. A device as in claim 10, wherein said air
2 infiltration detector is a detector of the presence of air
3 in said blood circuit.

1 17. A device for detecting leaks in a blood
2 circuit, comprising:

3 a first leak detector that detects leaks by
4 sensing blood outside said blood circuit, said first leak
5 detector being located to detect leaks from a first portion
6 of said blood circuit located remote from a patient;

7 a second leak detector that detects leaks by
8 sensing air infiltration into lines under negative
9 pressure;

10 said second leak detector being configured to
11 detect leaks in lines connecting said patient to said first
12 portion;

13 a mechanism that insures that at least part of
14 said lines are under negative pressure at least part of the
15 time during a treatment such that a detectable air
16 infiltration indicates a presence of a leak in said lines;

17 an alarm device that outputs an alarm signal
18 responsively to a detection of a leak by said first or
19 second leak detector.

1 18. A device as in claim 17, wherein said second
2 leak detector includes a fluid sensor below said circuit
3 first portion.

1 19. A device as in claim 17, wherein said
2 mechanism includes a flow-reversing valve in said blood
3 circuit effective to reverse flow in said lines.

1 20. A device as in claim 17, where in said first
2 leak detector is located below said first portion, said
3 device further comprising a flow director to concentrate
4 leaking fluid toward said first leak detector.

1 21. A method of detecting a fluid leak from a
2 fluid processing machine, comprising the steps of:

3 detecting infiltration of air into a fluid
4 circuit;

5 detecting leakage of fluid from said fluid
6 circuit;

7 generating an alarm responsively to said first
8 and second steps of detecting.

22. A method as in claim 21, wherein said step of generating includes generating an alarm when either of said steps of detecting indicates a leak.

23. A method as in claim 21, wherein said first step of detecting is restricted to detecting infiltration into a first part of said fluid circuit and said second step of detecting is restricted to detecting fluid leaking from a second part of said fluid circuit, said first and second parts having separate respective portions.

24. A method as in claim 21, wherein said first step of detecting includes generating a negative pressure in said fluid circuit.

25. A method as in claim 25, wherein said step of generating includes reversing a flow of fluid.

26. A method as in claim 21, wherein said fluid is blood.

27. A method as in claim 21, wherein said fluid processing machine is an extracorporeal blood processing machine.

28. A method of detecting a leak from a blood circuit of an extracorporeal blood treatment machine, comprising the steps of:

31 detecting leakage of blood from respective
32 portions of a blood circuit;

33 said step of detecting including detecting
34 different physical effects resulting from respective
35 conditions associated with one or more leaks;

36 said respective portions including parts that are
37 non-overlapping.

38 29. A method as in claim 28, wherein said step
39 of detecting includes triggering an indicator of a leak
40 responsively to a result of either of said respective
41 different physical effects.

42 30. A method as in claim 29, further comprising
43 at least one of clamping a fluid line, stopping a pump, or
44 actuating a flow controller responsively to said indicator.

45 31. A method as in claim 29, further comprising
46 triggering an alarm responsively to said indicator.

47 32. A method as in claim 28, wherein said
48 different physical effects include the infiltration of air
49 into a blood circuit and the presence of blood outside said
50 blood circuit.

51 33. A method as in claim 32, further comprising
52 controlling an output device responsively to said
53 indicator.

54 34. A method as in claim 32, further comprising
55 at least one of clamping a fluid line, stopping a pump, or
56 actuating a flow controller responsively to said indicator.

57 35. A method as in claim 32, further comprising
58 outputting an alarm signal responsively to said indicator.

59 36. A method as in claim 35, wherein said step
60 of detecting includes triggering an indicator of a leak
61 responsively to a result of either of said respective
62 different physical effects.

63 37. A method as in claim 36, wherein said
64 different physical effects include the infiltration of air
65 into a blood circuit and the presence of blood outside said
66 blood circuit.

67 38. A method as in claim 28, wherein said
68 different physical effects include the infiltration of air
69 into a blood circuit by periodically generating a negative
70 pressure in said blood circuit and the presence of blood
71 outside said blood circuit.

72 39. A method as in claim 38, wherein said step
73 of generating includes reversing a flow of blood.

74 40. A method as in claim 28, wherein said
75 different physical effects include the infiltration of air
76 into a blood circuit by periodically reversing a flow of

77 blood in said blood circuit using a reversing valve and the
78 presence of blood outside said blood circuit.

79 41. A method as in claim 40, wherein said
80 presence is detected using a sensor located inside a
81 housing of said extracorporeal blood treatment machine.

82 42. A method as in claim 40, wherein said
83 presence is detected by guiding and concentrating a leaking
84 flow of blood toward a fluid sensor.

85 43. A device for detecting a fluid leak from a
86 fluid processing machine, comprising the steps of:

87 an air detection sensor located to detect
88 infiltration of air into a fluid circuit of said fluid
89 processing machine;

90 a fluid detector located to detect a leakage of
91 fluid from said fluid circuit;

92 an alarm connected to said sensor and said fluid
93 detector and configured to output an alarm signal
94 responsively to signals therefrom.

95 44. A device as in claim 43, wherein said alarm
96 is adapted to output said alarm signal when either said
97 sensor or said fluid detector indicates a leak.

98 45. A device as in claim 43, wherein said sensor
99 is located to detect infiltration into a first part of said

100 fluid circuit and said fluid detector is located to detect
101 fluid from a second part of said fluid circuit, said first
102 and second parts having separate respective portions.

103 46. A device as in claim 43, further comprising
104 a mechanism adapted to generate a negative pressure in said
105 fluid circuit to cause air to infiltrate into a breach in
106 said fluid circuit.

107 47. A device as in claim 46, wherein said
108 mechanism is adapted to reverse a direction of flow of
109 fluid in said fluid circuit.

110 48. A device as in claim 43, wherein said fluid
111 circuit is a blood circuit.

112 49. A device as in claim 43, wherein said fluid
113 processing machine is an extracorporeal blood processing
114 machine.

115 50. A device for detecting a leak from a blood
116 circuit of an extracorporeal blood treatment machine,
117 comprising the steps of:

118 respective detectors located to detect leaks of
119 blood from respective portions of a blood circuit;

120 at least two of said respective detectors
121 including sensors configured to detect different physical
122 effects correlated with one or more blood leaks;

123 said respective portions including parts that are
124 non-overlapping.

125 51. A device as in claim 50, further comprising
126 an output device connected to receive signals from said
127 respective detectors and to output a signal responsively
128 thereto.

129 52. A device as in claim 51, further comprising
130 at least one of a fluid line clamp, a pump, and an actuator
131 of a flow controller, connected to be controlled by said
132 output device responsively to said signal.

133 53. A device as in claim 51, further comprising
134 an alarm connected to be triggered by said signal.

135 54. A device as in claim 50, wherein said
136 different physical effects include the infiltration of air
137 into a blood circuit and the presence of blood outside said
138 blood circuit.

139 55. A device as in claim 54, further comprising
140 an alarm connected to receive signals from said respective
141 detectors and to output a signal responsively thereto.

142 56. A device as in claim 54, further comprising
143 an output device connected to receive signals from said
144 respective detectors and to output a signal responsively
145 thereto and at least one of a fluid line clamp, a pump, and

146 an actuator of a flow controller, connected to be
147 controlled by said output device responsively to said
148 signal.

149 57. A device as in claim 54, further comprising
150 an output device connected to receive signals from said
151 respective detectors and to output a signal responsively
152 thereto and an alarm connected to generate an output
153 responsively to said signal.

154 58. A device as in claim 57, wherein said output
155 device and detectors are configured such that said signal
156 indicates a leak if either of either of said respective
157 different physical effects indicates a leak.

158 59. A device as in claim 58, wherein said
159 different physical effects include the infiltration of air
160 into a blood circuit and the presence of blood outside said
161 blood circuit.

162 60. A device as in claim 59, wherein at least
163 one of said detectors includes an air sensor and a
164 mechanism adapted to periodically generate a negative
165 pressure in said blood circuit such that air infiltrates
166 said blood circuit through any openings therein.

167 61. A device as in claim 60, wherein said
168 mechanism includes a mechanism adapted to reverse flow.

169 62. A device as in claim 50, further comprising
170 a reversing valve, said different physical effects include
171 the infiltration of air into said blood circuit caused by
172 periodically reversing a flow of blood in said blood
173 circuit using said reversing valve.

174 63. A device as in claim 62, wherein said
175 detectors include a fluid sensor located inside a housing
176 of said extracorporeal blood treatment machine.

177 64. A device as in claim 63, further comprising
178 a flow guide adapted to guide and concentrate a leaking
179 flow of blood toward said fluid sensor.